

WE CLAIM:

-1-

A compound which comprises:

a metal (M) complex with an imido ligand (N-R) bound to the M to provide an M=N-R site, a carbon (C) bound to the M to provide an M=C reaction site, a substituted carbon or carbon and heteroatom (N,S,O) containing 1 to 12 carbon atoms which tethers the C of the M=C reaction site to the R of the M=N-R site, and two to four ligands (R') bound to the M to provide two to four M-R' sites;

wherein the M is selected from the group consisting of molybdenum and tungsten; the R and R' are each independently selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic; and, the R' can be interconnected.

-2-

The compound of Claim 1 wherein the R' are interconnected and each M-R' bond is between the M and an oxygen of a dialkoxide ligand or a nitrogen of an  $\eta^1$ -pyrrolyl ligand.

-3-

The compound of Claim 2 wherein the  $\eta^1$ -pyrrolyl ligand is N,N-di(pyrrolyl- $\alpha$ -methyl)-N-methylamine (dpma).

-4-

The compound of Claim 1 wherein the R' is 1,2-dimethoxyethane or 3,3'-di-tert-butyl-5,5',6,6'-tetramethyl-1,1'-biphenyl-2,2'-diol.

-5-

The compound of Claim 1 wherein the M is molybdenum.

-6-

The compound of Claim 1 wherein the substituted alkyl chain between the C of the M=C and the R of the M=N-R comprises a backbone of 1 to 12 carbon atoms.

-7-

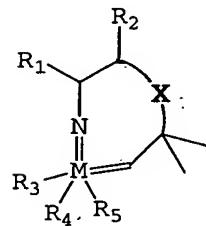
The compound of Claim 1 wherein the substituted alkyl chain between the C of the M=C and the R of the M=N-R is  $-C(CH_3)_2CH_2CH_2-$ .

-8-

The compound of Claim 1 wherein the compound is immobilized on a solid support.

A compound comprising the formula

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wherein M is a metal ion selected from the group consisting of Mo and W; wherein x is a carbon or carbon and heteroatom chain containing 1 to 12 carbon atoms; R<sub>1</sub> and R<sub>2</sub> can independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, substituted cyclic, and hydrogen; R<sub>1</sub> and R<sub>2</sub> can be interconnected to each other; R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> can be independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic; R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> can be interconnected to each other; R<sub>3</sub> and R<sub>4</sub> can be interconnected to each other and R<sub>5</sub> can be absent; and R<sub>3</sub> and R<sub>4</sub> are separate and R<sub>5</sub> is absent.

The compound of Claim 9 wherein n is 2.

The compound of Claim 9 wherein R<sub>1</sub> and R<sub>2</sub> are adjacent carbons in an aromatic ring.

The compound of Claim 9 wherein M is molybdenum.

-13-

The compound of Claim 9 wherein the R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> are interconnected nitrogens of N,N-di(pyrrolyl- $\alpha$ -methyl)-N-methylamine (dpma) and each of the bonds with the M is via a separate nitrogen of the dpma.

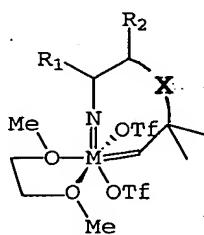
-14-

The compound of Claim 9 wherein the R<sub>3</sub> and R<sub>4</sub> are interconnected oxygens of a dialkoxide and each of the bonds with the M is via a separate oxygen of the dialkoxide.

-15-

A compound comprising the formula

5



wherein M is a metal ion selected from the group consisting of Mo and W; x is a carbon or carbon and heteroatom (N,O,S) containing 1 to 12 carbon atoms; OTf is a triflate; R<sub>1</sub> and R<sub>2</sub> can independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, substituted cyclic, and hydrogen; and, R<sub>1</sub> and R<sub>2</sub> can be interconnected to each other.

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15

-16-

The compound of Claim 15 wherein x is -  
(CH<sub>3</sub>)<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>-.

-17-

The compound of Claim 15 wherein  $R_1$  and  $R_2$  are adjacent carbons in an aromatic ring.

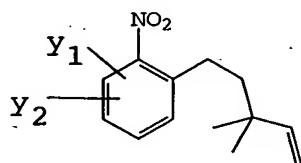
-18-

The compound of Claim 15 wherein M is molybdenum.

-19-

A compound comprising the formula

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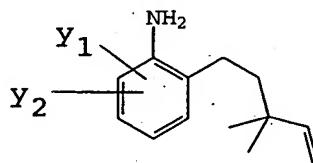


wherein  $y_1$  and  $y_2$  are each selected from the group consisting of hydrogen and lower alkyl containing 1 to 12 carbon atoms.

-20-

A compound comprising the formula

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wherein  $y_1$  and  $y_2$  are each selected from the group consisting of hydrogen and lower alkyl containing 1 to 12 carbon atoms.

-21-

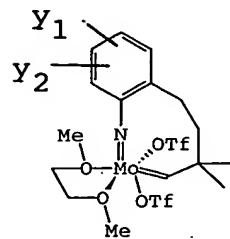
A compound comprising  $MoCl_2(NAr)_2(dme)$  wherein Ar is aryl and dme is dimethylethane and the N is bound to the Mo via an imido bond.

-44-

A compound comprising  $\text{Mo}(\text{nph})_2(\text{NAr})_2$  wherein Ar is aryl and nph is neophyl or neopentyl and the N is bound to the Mo via an imido bond.

A compound comprising the formula

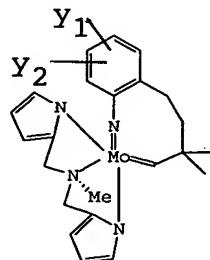
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wherein OTf is a triflate, and wherein  $y_1$  and  $y_2$  are each selected from the group consisting of hydrogen and lower alkyl containing 1 to 12 carbon atoms.

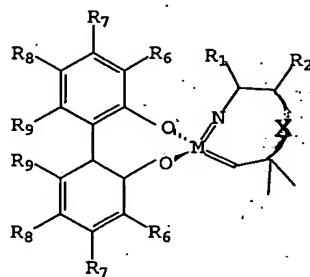
A compound comprising the formula

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wherein  $y_1$  and  $y_2$  are each selected from the group consisting of hydrogen and lower alkyl containing 1 to 12 carbon atoms.

A compound which has the structure



wherein M is a metal ion selected from the group consisting of Mo and W; x is a carbon group or a carbon and heteroatom (NOS) chain containing 1 to 12 carbon atoms; R<sub>1</sub> and R<sub>2</sub> can independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, substituted cyclic, and hydrogen; R<sub>1</sub> and R<sub>2</sub> can be interconnected to each other; R<sub>6</sub>, R<sub>7</sub>, R<sup>8</sup>, and R<sub>9</sub> can be independently be selected from the group consisting of hydrogen, alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic.

A process for metathesizing an olefin which comprises:

(a) contacting the olefin in a solvent with a metal (M) complex comprising an imido ligand (N-R) bound to the M to provide an M=N-R site, a carbon (C) bound to the M to provide an M=C reaction site, a substituted carbon or carbon and heteroatom (N,S,O) containing 1 to 12 carbon atoms which tethers the C of the M=C reaction site to the R of the M=N-R site, and two to four ligands (R') bound to the M to provide two to four M-R' sites;

wherein the M is selected from the group consisting of molybdenum and tungsten; the R and R' are each independently selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic; and, the R' can be interconnected, to metathesize the olefin; and

(b) separating the metathesized olefin in the solvent from the catalyst.

The process of Claim 26 wherein the R' are interconnected and each M-R' bond is between the M and an oxygen of a dialkoxide ligand or a nitrogen of an  $\eta^1$ -pyrrolyl ligand.

The process of Claim 27 wherein the  $\eta^1$ -pyrrolyl ligand is N,N-di(pyrrolyl- $\alpha$ -methyl)-N-methylamine (dpma).

The process of Claim 26 wherein the R' is 1,2-dimethoxyethane or 3,3'-di-*tert*-butyl-5,5',6,6'-

tetramethyl-1,1'-biphenyl-2,2'-diol.

-30-

The process of Claim 26 wherein the M is molybdenum.

-31-

The process of Claim 26 wherein the chain between the C of the M=C and the R of the M=N-R comprises an alkylene backbone of 1 to 8 carbon atoms.

-32-

The process of Claim 26 wherein the chain between the C of the M=C and the R of the M=N-R is  $\text{C}(\text{CH}_3)_2\text{CH}_2\text{CH}_2-$ .

-33-

The process of Claim 26 wherein the catalyst is immobilized on a solid support.

-34-

The process of Claim 26 wherein the metathesis is selected from the group consisting of ring-closing metathesis and ring-opening cyclooligomerization metathesis.

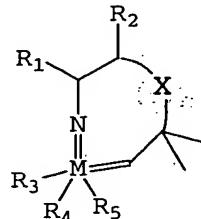
-49-

A process for metathesizing an olefin which comprises:

(a) contacting the olefin in a solvent with a metal (M) catalyst which has the formula

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wherein x is a carbon or carbon and heteroatom chain containing 1 to 12 carbon atoms; R<sub>1</sub> and R<sub>2</sub> can independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, substituted cyclic, and hydrogen; R<sub>1</sub> and R<sub>2</sub> can be interconnected to each other; R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> can be independently be selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic; R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> can be interconnected to each other; R<sub>3</sub> and R<sub>4</sub> can be interconnected to each other and R<sub>5</sub> can be absent, and R<sub>3</sub> and R<sub>4</sub> can be separate from each other and R<sub>5</sub> is missing, to metathesize the olefin; and

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(b) separating the metathesized olefin in the solvent from the catalyst.

-36-

The process of Claim 35 wherein n is 2.

-37-

The process of Claim 35 wherein R<sub>1</sub> and R<sub>2</sub> are adjacent carbons in an aromatic ring.

-38-

The process of Claim 35 wherein M is molybdenum.

-39-

The process of Claim 35 wherein the R<sub>3</sub>, R<sub>4</sub>, and R<sub>5</sub> are interconnected nitrogens of N,N-di(pyrrolyl- $\alpha$ -methyl)-N-methylamine (dpma) and each of the bonds with the M is via a separate nitrogen of the dpma.

-40-

The process of Claim 35 wherein the R<sub>3</sub> and R<sub>4</sub> are interconnected oxygens of a dialkoxide and each of the bonds with the M is via a separate oxygen of the dialkoxide.

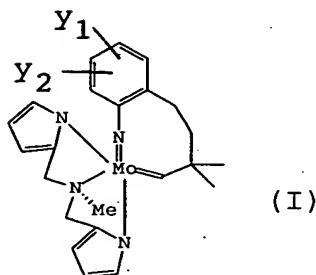
-41-

The process of Claim 35 wherein the catalyst is immobilized on a solid support.

-42-

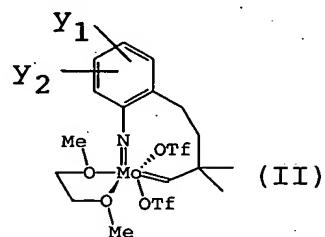
The process of Claim 35 wherein the metathesis is selected from the group consisting of ring-closing metathesis and ring-opening cyclooligomerization metathesis.

A process for preparing a molybdenum catalyst (I) of the formula



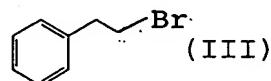
wherein  $y_1$  and  $y_2$  are each selected from the group consisting of hydrogen and lower alkyl containing 1 to 12 carbon atoms, which comprises:

reacting a compound (II) of the formula

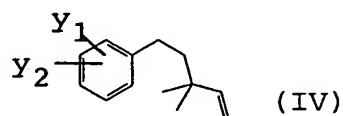


with  $N,N$ -di(pyrryl- $\alpha$ -methyl)- $N$ -methylamine lithium salt to make the molybdenum catalyst (I).

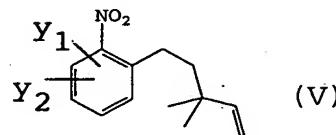
The process of Claim 43 wherein compound (II) is prepared by a process which comprises reacting a compound (III) of the formula



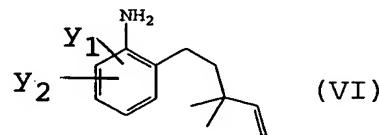
with 2-methyl-4-ZnBr-2-butene, to produce compound (IV) having the formula



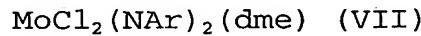
reacting the compound (IV) with nitric acid/ acetic acid/ acetic anhydride to produce compound (V) having the formula



reacting compound (V) with  $\text{SnCl}_2$  and an acid to produce compound (VI) having the formula



reacting compound (VI) with dimolybdate, chlorotrimethylsilane, and triethylamine to produce compound (VII) having the formula



wherein Ar is aryl and dme is dimethylethane and the N is bound to the Mo via an imido bond;

reacting compound (VII) with neophylyl (nph)  $\text{MgCl}$  to produce compound (VIII) having the formula



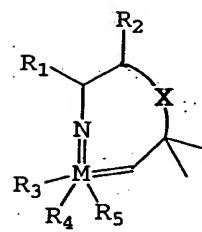
wherein Ar is aryl and nph is neophylyl and the N is bound to the Mo via an imido bond; and,

reacting compound (VIII) with triflic acid in DME to produce the compound (II).

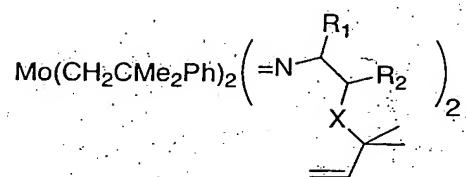
A process for the preparation of a Mo or W catalyst which comprises reacting a compound which comprises: a metal (M) complex with an imido ligand (N-R) bound to the M to provide an M=N-R site, a carbon (C) bound to the M to provide an M=C reaction site, a substituted carbon or carbon and heteroatom (N,S,O) containing 1 to 12 carbon atoms which tethers the C of the M=C reaction site to the R of the M=N-R site, and two to four ligands (R') bound to the M to provide two to four M-R' sites;

wherein the M is selected from the group consisting of molybdenum and tungsten; the R and R' are each independently selected from the group consisting of alkyl, heteroalkyl, substituted alkyl, aryl, heteroaryl, substituted aryl, cyclic, heterocyclic, and substituted cyclic; and the R' can be interconnected.

A process for the preparation of a M or W catalyst of the formula:



which comprises reacting a compound



and a molar excess of triflic acid and dimethoxymethane (DME) to form the catalyst.